



System Advisor Model Introduction

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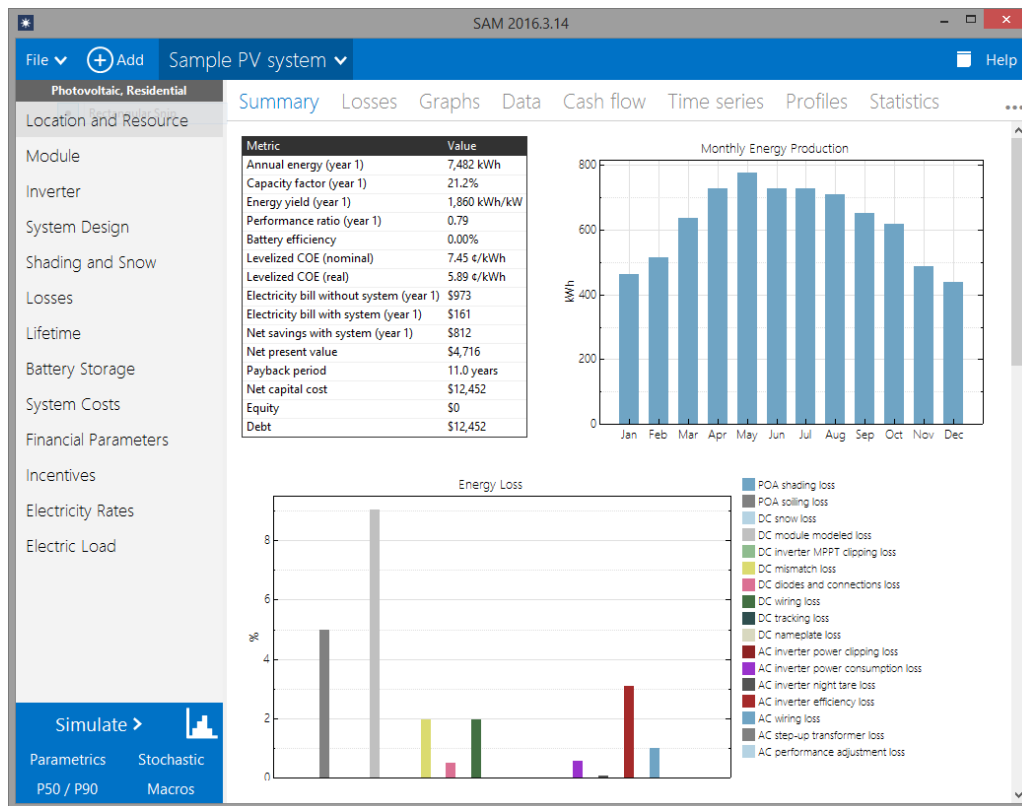


Outline

- SAM Introduction
- Photovoltaic Model
- Battery Model

System Advisor Model (SAM)

Free software that combines detailed performance and financial models to estimate the cost of energy for systems



<http://sam.nrel.gov/download>

Technologies

Photovoltaics, detailed & PVWatts

Battery storage

Concentrating solar power

Wind

Geothermal

Biomass

Solar water heating

Financials

Behind-the-meter

residential

commercial

Power purchase agreements

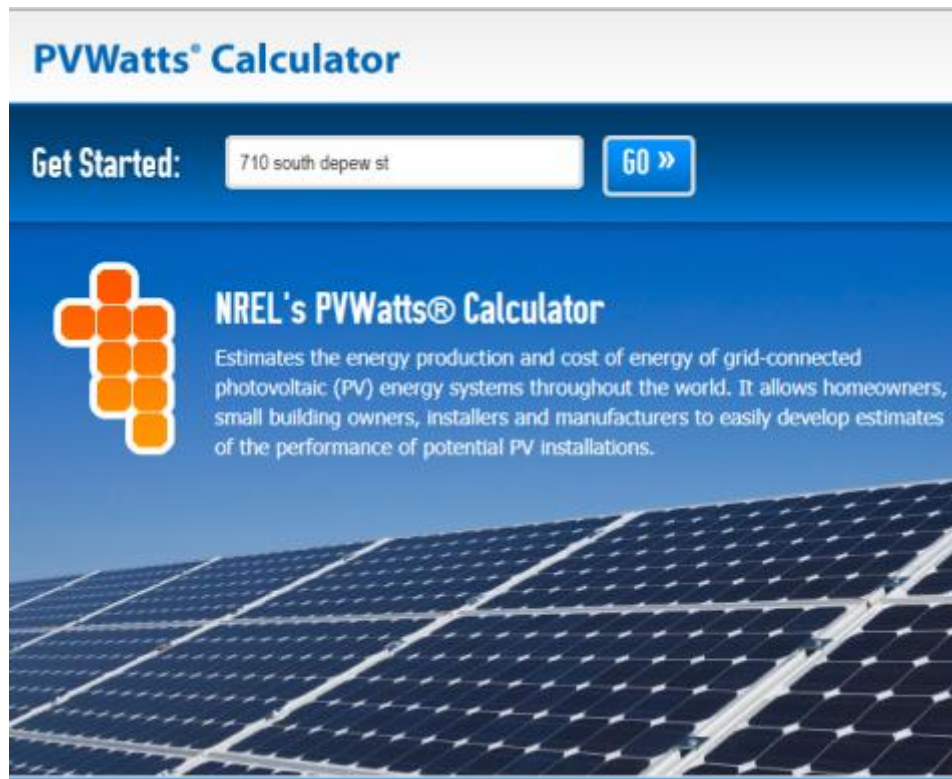
single owner

equity flips

sale-leaseback

Simple LCOE calculator

PVWatts or SAM?



*The SAM team maintains the PVWatts model, and it's included with SAM.

PVWatts

- Provides a simple performance and financial assessment for smaller-scale PV systems given an address, system design, and simple \$/kWh electricity rate.

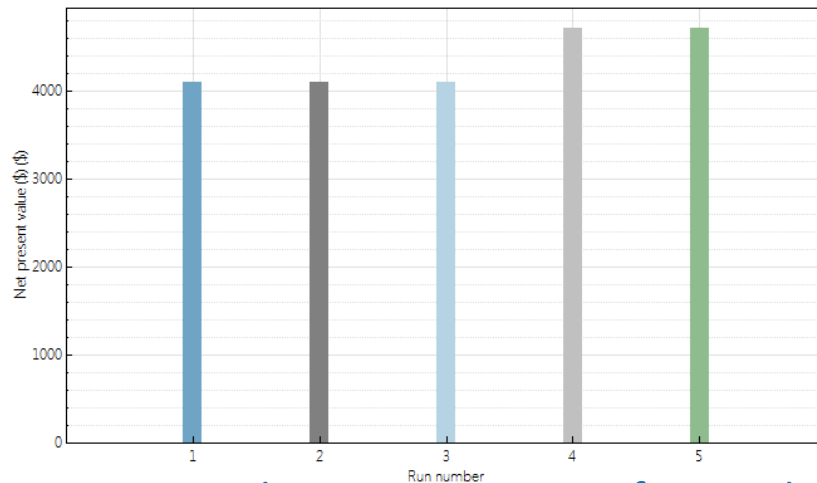
SAM

- Provides detailed performance assessment for small to utility scale systems
- Model complex shading and other losses.
- Can model detailed financial parameters, including complex utility rate tariffs, incentives.
- Models custom load profiles.
- Detailed outputs and visualization

Questions you can answer with SAM

Metric	Value
Annual energy (year 1)	7,482 kWh
Capacity factor (year 1)	21.2%
Energy yield (year 1)	1,860 kWh/kW
Performance ratio (year 1)	0.79
Battery efficiency	0.00%
Levelized COE (nominal)	7.45 ¢/kWh
Levelized COE (real)	5.89 ¢/kWh
Electricity bill without system (year 1)	\$973
Electricity bill with system (year 1)	\$161
Net savings with system (year 1)	\$812
Net present value	\$4,716
Payback period	11.0 years
Net capital cost	\$12,452
Equity	\$0
Debt	\$12,452

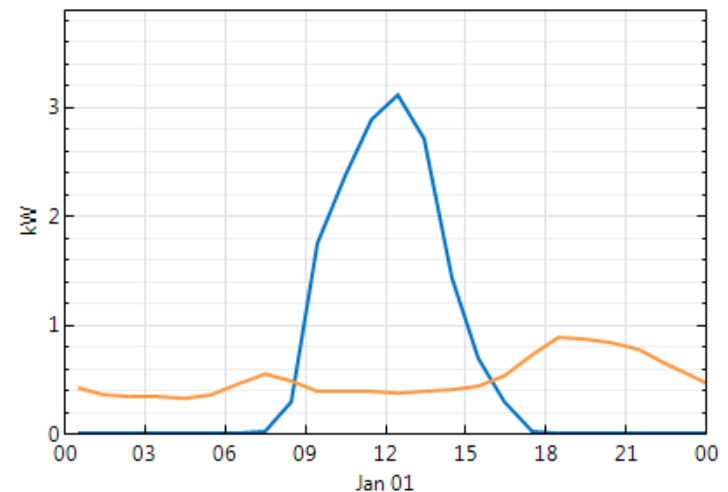
- Predicted technical and financial performance over project lifetime



- System design to maximize financial return

Summary	Losses	Graphs	Data	Cash flow	Time series	Profiles	Statistics
Copy to clipboard	Save as CSV	Send to Excel	Send to Excel with Equations				
	0	1	2	3	4	5	
PRODUCTION							
Energy (kWh)	0	7,482	7,484	7,407	7,370	7,333	
SAVINGS							
Value of electricity savings (\$)	0	812	831	851	870	889	
OPERATING EXPENSES							
O&M fixed expense (\$)	0	0	0	0	0	0	
O&M production-based expense (\$)	0	0	0	0	0	0	
O&M capacity-based expense (\$)	0	80	82	85	87	89	
Battery replacement cost (\$)	0	0	0	0	0	0	
Property tax expense (\$)	0	125	125	125	125	125	
Insurance expense (\$)	0	125	128	131	134	137	
Net salvage value (\$)	0	0	0	0	0	0	
Total operating expense (\$)	0	329	335	340	345	351	
Deductible expenses (\$)	0	-125	-125	-125	-125	-125	
PROJECT DEBT							
Debt balance (\$)	12,452	12,191	11,917	11,630	11,328	11,011	
Interest payment (\$)	0	623	610	596	581	566	
Principal payment (\$)	0	261	274	288	302	317	
Total P&I debt payment (\$)	0	884	884	884	884	884	

- Detailed cash-flow financials



- Time series behavior of system performance

Detailed photovoltaic model

Irradiance

Transposition using Isotropic, HDKR, or Perez
Measured plane of array (POA) input

Shading

Irregular obstruction shading from 3D scene
Self-shading for regularly spaced rows
External input from SunEye, Solar Pathfinder
Snow cover loss model

Module

Simple efficiency model
Single diode model (CEC database or datasheet)
Extended single diode model (for IEC-61853 tests)
Sandia PV Array Performance Model

Inverter

Sandia/CEC grid-tied inverter model
Datasheet part-load efficiency curve

System

Sizing wizard or electrical layout
Multiple subarrays
Fixed, 1 axis, backtracking, azimuth axis, 2 axis
Battery storage

Degradation

Extrapolated single year
Lifetime simulation of all years

Simulation

1 minute to 1 hour time steps

SAM 2016.3.14

File Add untitled

Photovoltaic, Residential

Location and Resource

Module

Inverter

System Design

Shading and Snow

Losses

Lifetime

Battery Storage

System Costs

Financial Parameters

Incentives

Electricity Rates

Electric Load

Download a weather file from the NREL National Solar Radiation Database

Click Download and type a street address or latitude and longitude to download a weather file from the NREL National Solar Radiation Database (NSRDL). SAM adds the downloaded file to the solar resource library so it will appear in the list below.

[View NREL NSRDL website](#)

Choose a weather file from the solar resource library

Click a name in the list to choose a file from the library. Type a few letters of the name in the search box to filter the list. If your location is not in the library, try downloading a file (see above).

Search for: Name

Name	Station ID	Latitude	Longitude	Time zone	Elevation
USA AR Stuttgart (arcs) (TMY3)	723416	34.6	-91.567	-6	66
USA AR Texarkana Webb Field (TMY3)	723418	33.45	-94	-6	110
USA AR Walnut Ridge (arcs) (TMY3)	723406	36.133	-90.317	-6	83
USA AZ Casa Grande (arcs) (TMY3)	722748	32.95	-110.767	-7	446
USA AZ Davis Monthan Afb (TMY3)	722745	32.167	-110.863	-7	809
USA AZ Deer Valley Phoenix (TMY3)	722794	33.683	-112.083	-7	450
USA AZ Douglas Bisbee-Douglas Intl A (TMY3)	722735	31.467	-109.6	-7	1249
USA AZ Flagstaff (TMY2)	03083	35.133	-111.667	-7	2135
USA AZ Flagstaff Pulliam Arpt (TMY3)	723755	35.133	-111.667	-7	2132
USA AZ Grand Canyon Natl P (TMY3)	723783	35.95	-112.15	-7	2085
USA AZ Kingman (arcs) (TMY3)	723700	35.267	-113.95	-7	1033
USA AZ Luke Afb (TMY3)	722785	33.55	-112.367	-7	330
USA AZ Page Muni (arcs) (TMY3)	723710	36.933	-111.45	-7	1304
USA AZ Phoenix (TMY2)	23183	33.433	-112.017	-7	339

City Time zone GMT -7 Latitude 33.4333 °N

State AZ Elevation 139 m Longitude -112.017 °E

Country USA Data Source TMY2 Station ID 23183

Data file C:\SAM\2016.3.14\solar_resource\USA AZ Phoenix (TMY2).csv

Annual Weather Data Summary

Global horizontal	5.80 kWh/m ² /day	Average temperature	22.5 °C
Direct normal (beam)	6.90 kWh/m ² /day	Average wind speed	3.0 m/s
Diffuse horizontal	1.35 kWh/m ² /day	Maximum snow depth	0 cm

[Visit SAM weather data website](#)

Use a specific weather file on disk

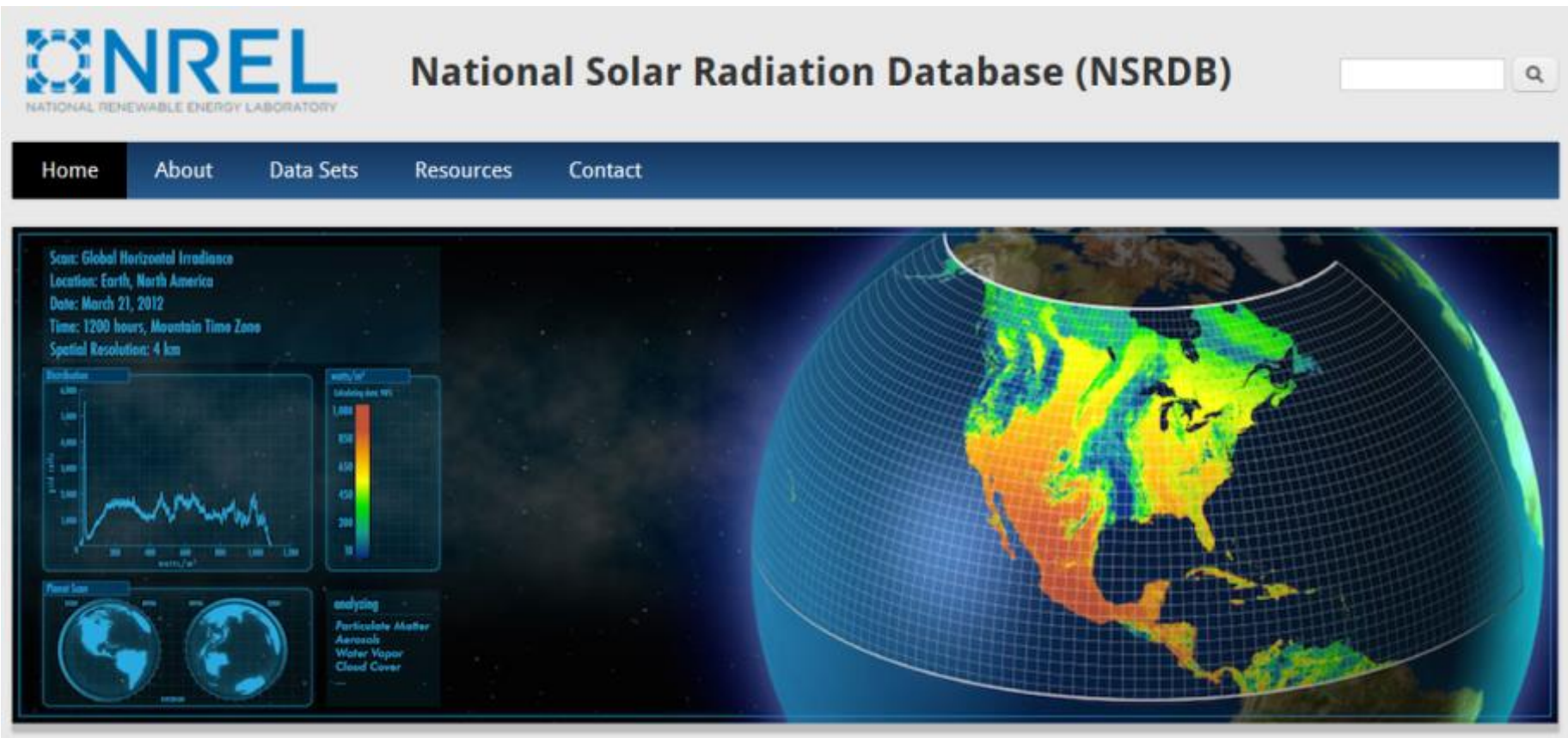
☐ Browse...

Check the box and click Browse to choose a weather file stored on your computer without adding it to the solar resource library. Supported solar weather file formats are SAM CSV, TMY2, TMY3, and EPW.

Simulate > Parameters Stochastic

Albedo - Sky Diffuse Model - Irradiance Data (Advanced)

Resource Data



- SAM allows selection from NREL NSRDB, TMY3, or input of a custom user defined weather file in an easy to use format.
- Multiple sources of data available: sam.nrel.gov/weather
- NSRDB – 4x4 km data at 30 minute resolution for North and Central America. 10x10 km hourly data for various countries in South Asia

Module and Inverter Modeling

IEC61853 Single Diode Model ▾

Module test data (according to IEC-61853)

	Import...	Irr(W/m ²)	Tc(K)	Pmp(W)	Vmp(V)	Voc(A)	Isc(A)
	Export...	100	15	6.69435	63.8967	79.5398	0.1175
	Copy	100	25	6.48283	61.6303	77.0356	0.118
	Paste	100	50	5.9371	55.8834	70.7751	0.1191
		100	75	5.36686	50.0207	64.5146	0.1203
Rows:		200	15	13.889	66.2978	82.4388	0.2350
		200	25	13.5153	64.2559	80.0352	0.236
		200	50	12.5576	59.1117	74.0262	0.2383
		200	75	11.5662	53.9109	68.0172	0.2407
		400	15	28.1891	67.3057	85.3378	0.4701
		400	25	27.4968	65.39	83.0348	0.472
		400	50	25.7322	60.5878	77.2773	0.4767
		400	75	23.9194	55.7673	71.5198	0.4814

-Additional information for parameter estimation

Number of cells in series 116

Type CdTe ▾

Calculate parameters

STC parameters (from test data)

Power (Pmp) 67.83 W Open circuit voltage (Voc) 87 V
Voltage (Vmp) 64.6 V Short circuit current (Isc) 1.18 A
Current (Imp) 1.05 A Efficiency 9.42083 %

Installation and thermal behavior

Area 0.72 m²
Nominal operating cell temp 44.9 C
Standoff height Ground or rack mounted ▾
Approximate mounting height One story building height or lower ▾

Optical and spectral behavior

Module cover Standard glass ▾
Air mass modifiers 0.9417 0.06516 -0.02022 0.00219 -9.1e-005

Calculated model parameters from IEC-61853 test data

STC parameters

Diode factor (n) 1.45071
Light current (I_l) 1.18951 A
Saturation current (I_o) 2.08522e-009 A
Bandgap voltage (E_g) 0.737668 eV

STC temp coeffs

alpha 0.000472001 A/C
beta -0.217 V/C
gamma -0.258849 %/C

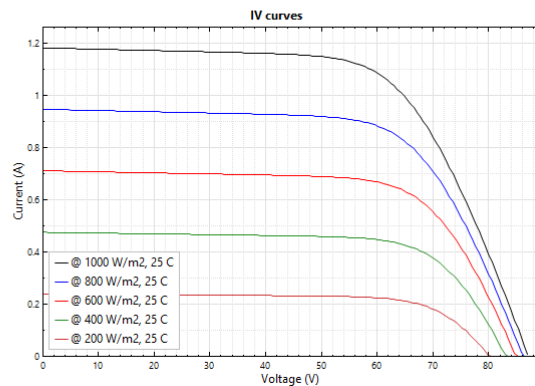
Rsh parameters

C1 1930.15
C2 474.64
C3 1.48746

Rs parameters

D1 13.5504
D2 -0.0769735
D3 0.237327

Update plot



Can choose which performance model to use (Simple, CEC, Sandia, IEC-61853)

Select module and inverter from a database maintained by the California Energy Commission or specify your own parameters from a datasheet or part load curve.

Dobos, A.; MacAlpine, S. Procedure for Applying IEC-61853 Test Data to a Single Diode Model. Proc. IEEE 40th PVSC Conf. Denver CO, June, 2014

System Design

Auto size the system or specify the module strings and inverters directly.

System Sizing

☐ Specify desired array size

Desired array size kWdc

DC to AC ratio

☒ Specify modules and inverters

Modules per string

Strings in parallel

Number of inverters

Configuration at Reference Conditions

Modules

Nameplate capacity kWdc

Number of modules

Modules per string

Strings in parallel

Total module area m²

String Voc V

String Vmp V

Inverters

Total capacity kWac

Total capacity kWdc

Number of inverters

Maximum DC voltage Vdc

Minimum MPPT voltage Vdc

Maximum MPPT voltage Vdc

Sizing messages (see Help for details):

Actual DC to AC ratio is 1.01.

Voltage and capacity ratings are at module reference conditions shown on the Module page.

Configure up to 4 sub-arrays, each with a specific:

- Tracking system
- Tilt
- Azimuth
- Ground Coverage Ratio
- Shading Table

3D shading calculator

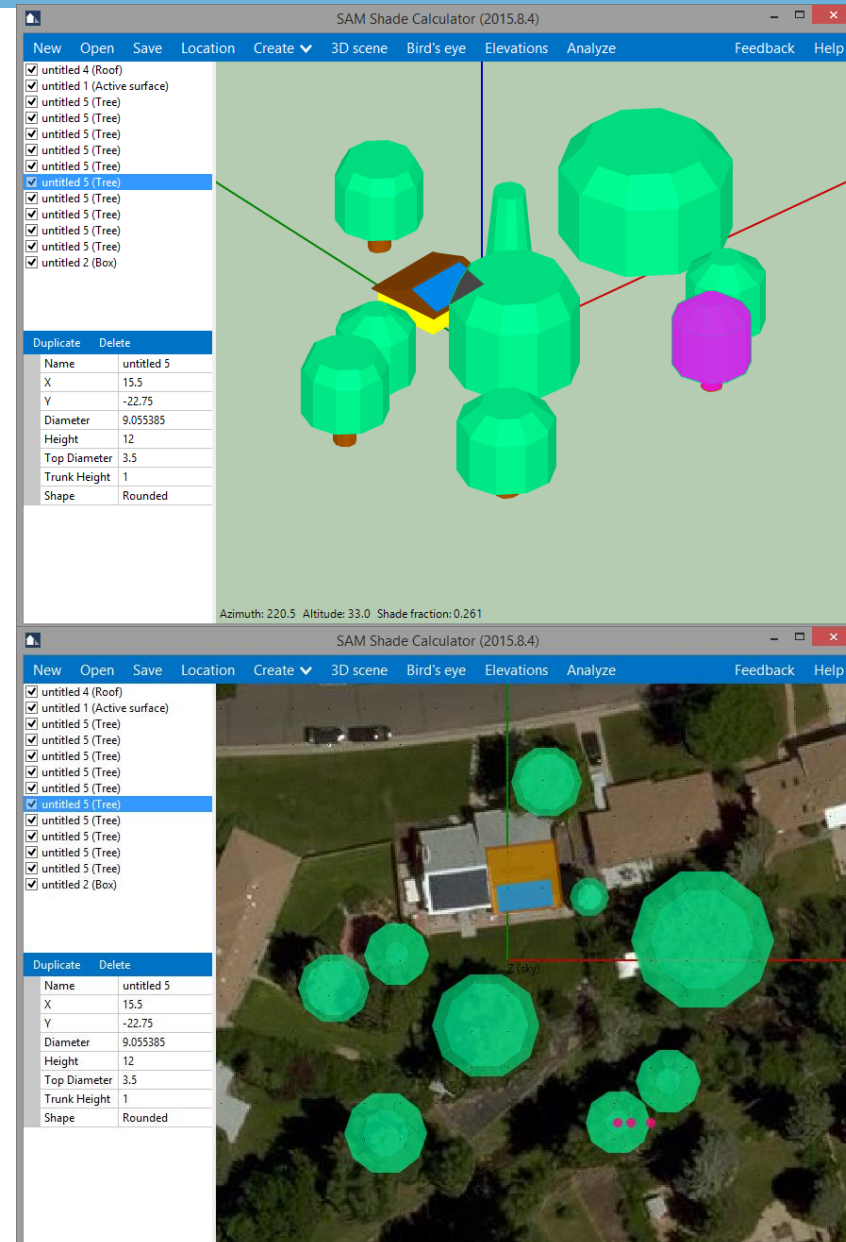
Calculates linear beam irradiance shading losses and sky diffuse view factor loss

Imports 2D mapping underlays from online maps

Outputs are diurnal or hourly/subhourly time series linear shade loss percentages

You can group PV surfaces into subarrays and specify parallel strings

Scripting to automate panel layout and import/export geometry data



Loss Modeling

- Irradiance Losses
 - Soiling
- DC Losses
 - Module mismatch
 - Wiring
 - Diodes and connections
- AC Losses
 - Wiring
 - Transformer

Financial Modeling

Financial models:

Residential (distributed)
Commercial (distributed)
Third party ownership
PPA single owner (utility)
PPA partnership flip with debt (utility)
PPA partnership flip without debt (utility)
PPA sale leaseback (utility)
LCOE calculator (FCR method)
No financial model



- | |
|--|
| <ul style="list-style-type: none">• Specify electric load• Specify utility rate structure |
| <ul style="list-style-type: none">• From perspective of off-taker (customer) |
| <ul style="list-style-type: none">• Utility scale systems with various ownership structures• Power purchase agreements specify value of selling power to grid throughout the year |
| <ul style="list-style-type: none">• Non cash-flow based fixed-charge rate method for calculating LCOE.• Best for market level (not project level) analysis. |
| <ul style="list-style-type: none">• If you are only interested in system performance, not financial performance |

All financial calculations generally require some information about system costs, loans, taxes, inflation rates, discount rates, depreciation, and other relevant parameters, depending on the model

Complex Utility Rate Tariffs



Wiki Apps Datasets Community

Home

U.S. Utility Rate Database

Weekday

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	4	4	4	4
Feb	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	4	4	4	4
Mar	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	4	4	4	4
Apr	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	4	4	4	4
May	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2
Jun	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2
Jul	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2
Aug	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2
Sep	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2
Oct	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2
Nov	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	4	4	4	4
Dec	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	4	4	4	4

Rate Structure for Energy Rates

Import...	Period	Tier	Max. Usage	Max. Usage Units	Buy (\$/kWh)	Sell (\$/kWh)
Export...	1	1	1e+038	kWh	0.26687	0.26687
Copy	2	1	1e+038	kWh	0.08328	0.08328
Paste	3	1	1e+038	kWh	0.22057	0.22057
	4	1	1e+038	kWh	0.08326	0.08326

Number of entries:

4

Utility Rate Database

- Tool in SAM to download and automatically populate complex inputs from utility rate database.
- <http://en.openei.org/apps/USURDB/>

Modeling

- Time-of-use energy and demand charges with ability to model usage tiers.
- Monthly demand charges
- Multiple metering and rollover options
- Convenient output of energy/demand charges by month, period, tier, etc.

Validation Studies



Validation of Multiple Tools for Flat Plate Photovoltaic Modeling Against Measured Data

Janine Freeman, Jonathan Whitmore,
Nate Blair, and Aron P. Dobos

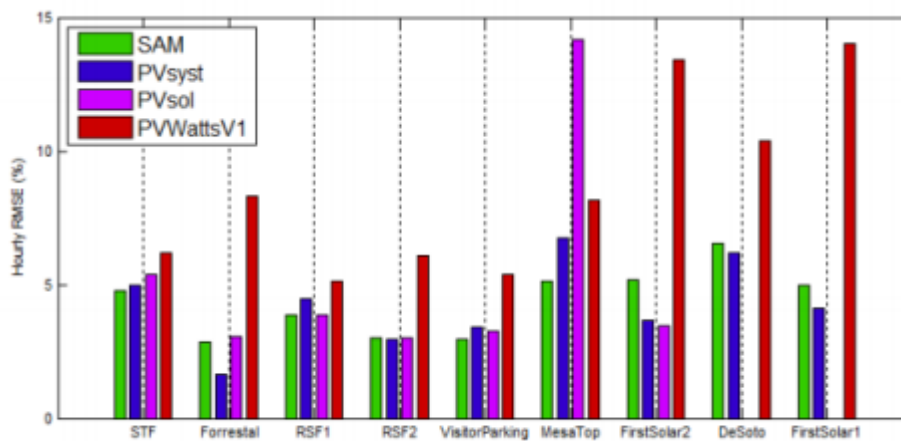


Figure 3. Normalized hourly RMSE of each tool, sorted in order of system size [1]

Photovoltaic Modeling

- Comparisons of SAM and other tools to measured performance data:
- Most recent study concluded SAM annual errors within +/- 8% of measured data
- <https://sam.nrel.gov/case-studies>

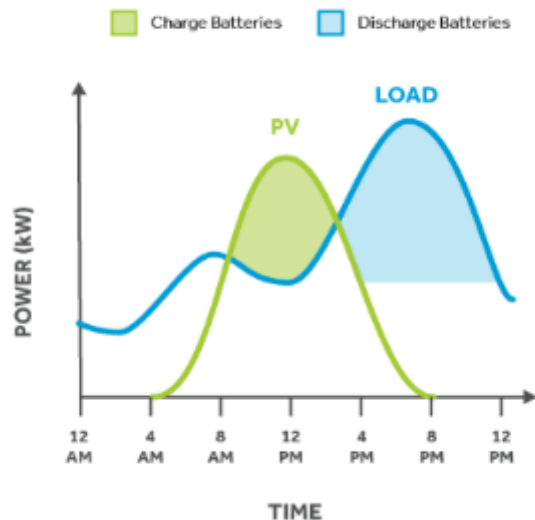
Upcoming Validation

- Comparison of SAM and other tools 3D shading calculations against SunEye measurements.
- Preliminary results suggest potentially large differences between tools

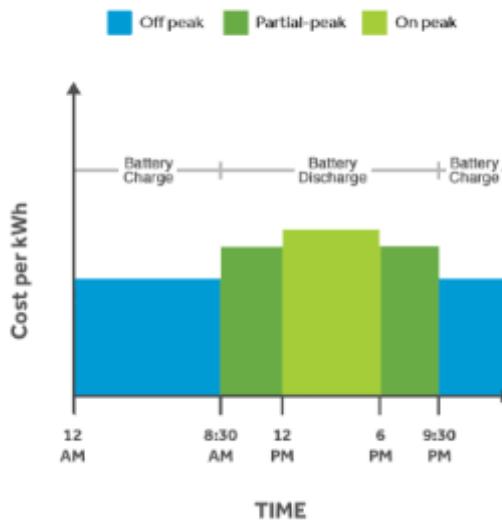
SAM Battery Model

Motivation for behind-the-meter storage

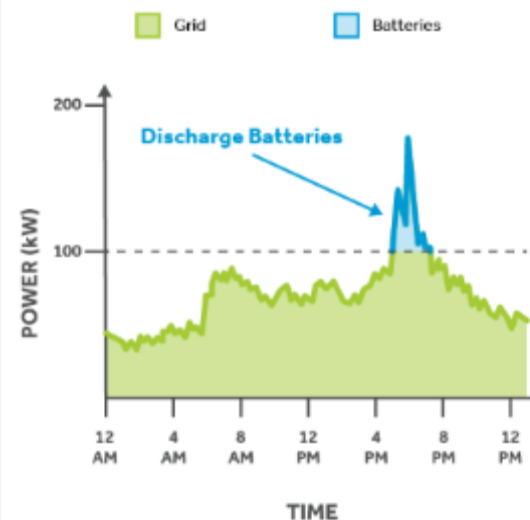
PV Self-Consumption



Time of Use Optimization



Demand Charge Reduction



Images from: <http://www.aquionenergy.com/>



- Batteries charged primarily from PV eligible for Federal ITC subject to 75% cliff
- End of NEM in some states



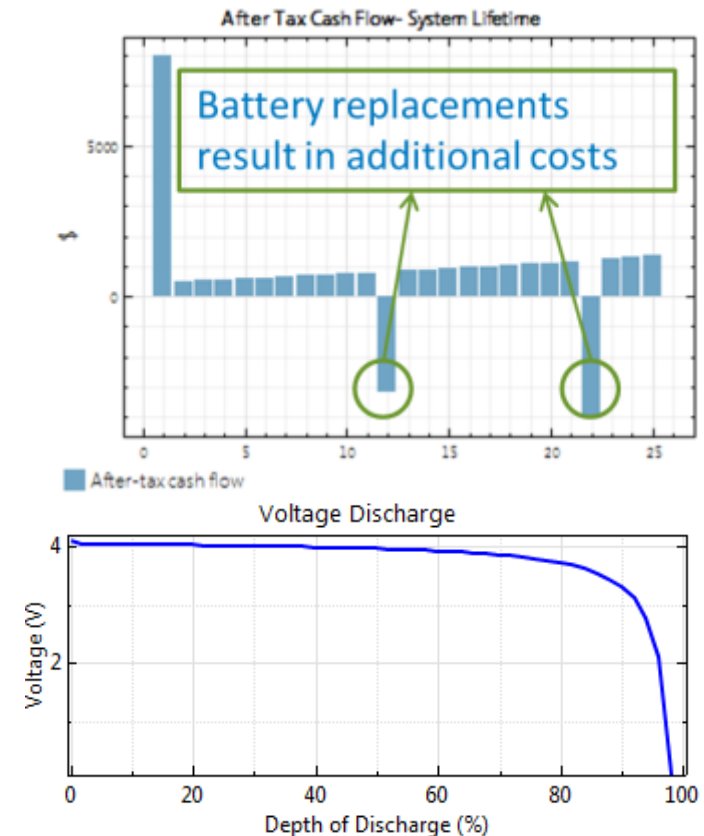
- Residential and commercial utility rate structures with high TOU charges.
- Charge when rate is low, discharge when rate is high



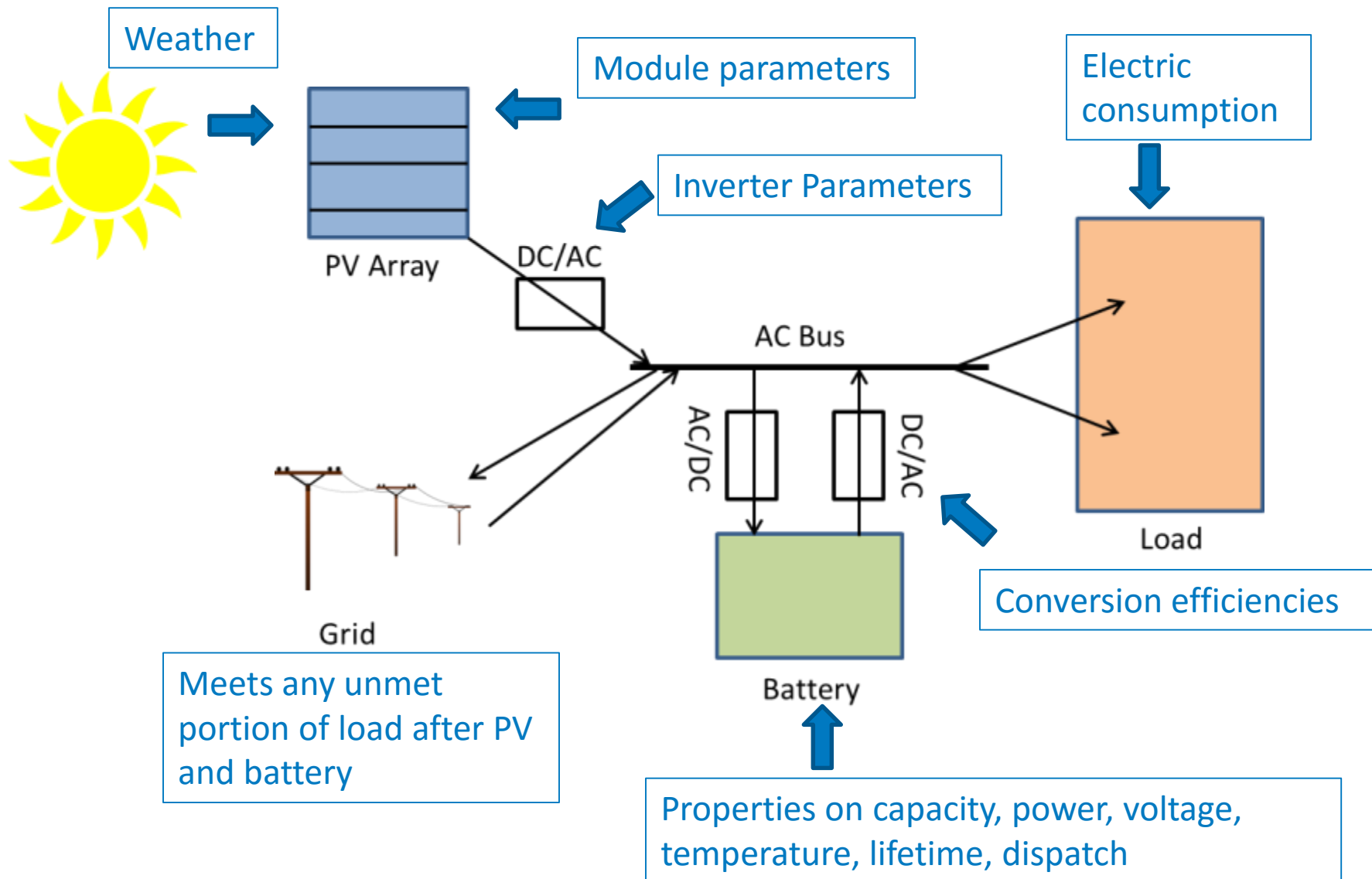
- Commercial utility structures can have very high TOU demand charges.

Model Overview

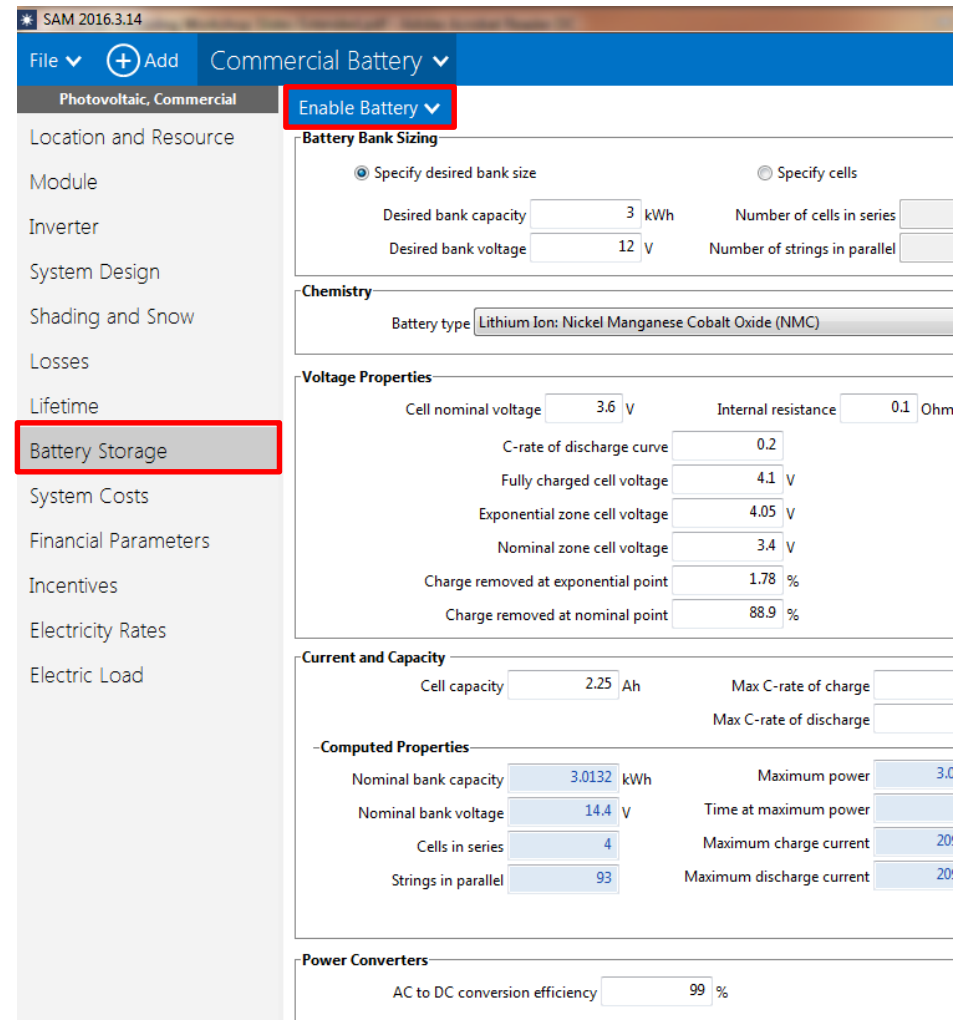
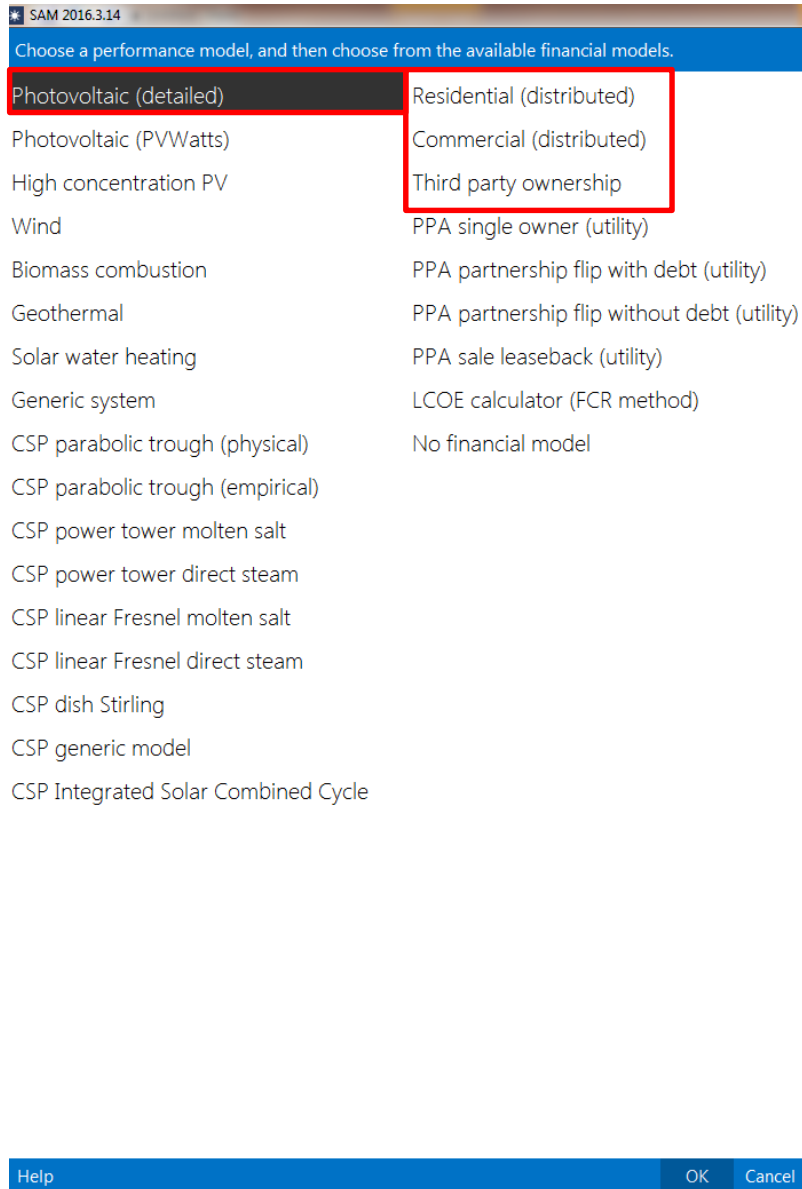
- Techno-economic model for residential, commercial, and third-party ownership systems
 - Lead acid & lithium ion battery chemistries
 - System lifetime analysis including battery replacement costs
 - Models for terminal voltage, capacity, temperature
 - Multiple dispatch controllers available



Modeled Configuration



Implementation in SAM



Battery Financials

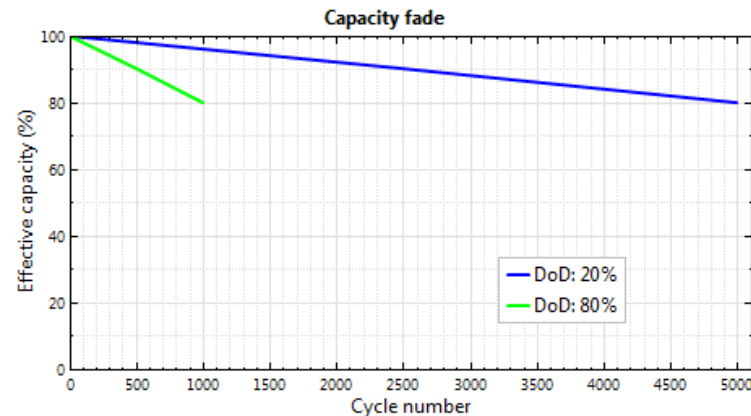
- Lifetime

PV simulation over analysis period ▼

PV Array Performance Degradation

Module degradation rate %/year

Applies to the array's hourly DC output.



Battery capacity fades with cycling, depends on depth-of-discharge

- System Costs

Direct Capital Costs

Module	<input type="text" value="928"/> units	<input type="text" value="0.2"/> kWdc/unit	<input type="text" value="199.8"/> kWdc	<input type="text" value="0.71"/> \$/Wdc	▼
Inverter	<input type="text" value="5"/> units	<input type="text" value="36.0"/> kWac/unit	<input type="text" value="180.0"/> kWac	<input type="text" value="0.21"/> \$/Wdc	▼
Battery bank	<input type="text" value="3.0"/> kWh dc	<input type="text" value="600.00"/> \$/kWh dc			

- Battery Bank Replacement (Battery Storage page)

Battery Bank Replacement

☒ No replacements

☐ Replace at specified capacity

☐ Replace at specified schedule

Battery bank replacement threshold % capacity

Battery bank replacement schedule

Battery bank replacement cost \$/kWh

Battery cost escalation above inflation %/year

SAM applies both inflation and escalation to the first year cost to calculate out-year costs. See Help for details.

Battery Dispatch

Storage Dispatch Controller

- Choose Dispatch Model

- ☐ Peak shaving: 1-day look ahead
- ☐ Peak shaving: 1-day look behind
- ☐ Automated grid power target
- ☒ Manual dispatch

- Charge Limits and Priority

Minimum state of charge %

Maximum state of charge %

Minimum time at charge state min

- Automated Grid Power Target Model

Single or monthly kW

Time series kW

- Manual Dispatch Model

	Charge from PV	Charge from grid	Discharge
		Allow % capacity	Allow % capacity
Period 1:	<input checked="" type="checkbox"/>	<input type="checkbox"/> 25	<input type="checkbox"/> 25
Period 2:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> 25	<input type="checkbox"/> 25
Period 3:	<input checked="" type="checkbox"/>	<input type="checkbox"/> 25	<input checked="" type="checkbox"/> 25
Period 4:	<input type="checkbox"/>	<input type="checkbox"/> 25	<input type="checkbox"/> 25
Period 5:	<input type="checkbox"/>	<input type="checkbox"/> 25	<input type="checkbox"/> 25
Period 6:	<input type="checkbox"/>	<input type="checkbox"/> 25	<input type="checkbox"/> 25

To activate the manual dispatch model, choose Manual Dispatch under "Choose Dispatch Model" above. These inputs are inactive for the automated dispatch options.

The manual dispatch model aims to minimize purchases from the grid. It first tries to meet load with PV, then battery, then grid. Choose whether PV should meet the load or charge the battery below. Use the timing controls to constrain the battery controller. See help for details.

- ☒ PV meets load before charging battery
- ☐ PV charges battery before meeting load

Weekday

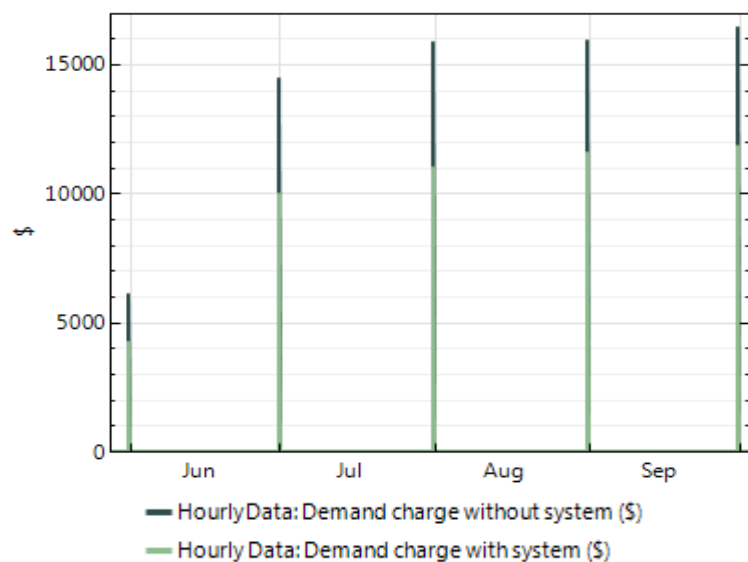
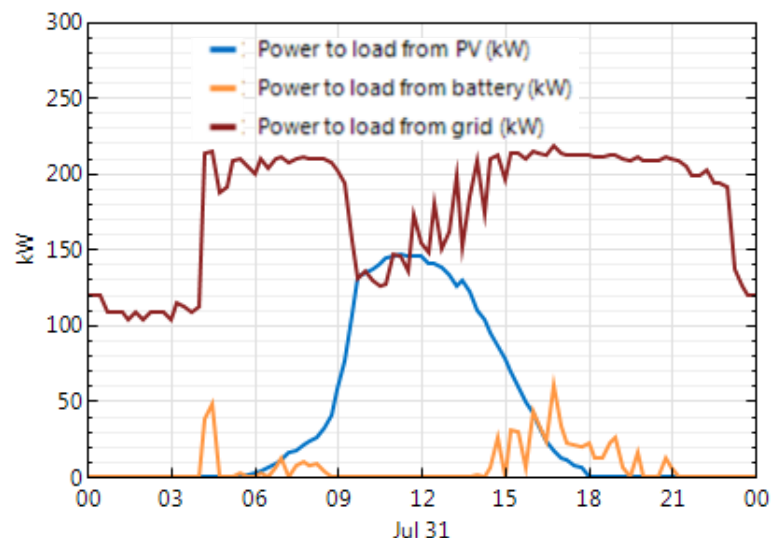
	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	1	1	1	1
Feb	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	1	1	1	1
Mar	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	1	1	1	1
Apr	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	1	1	1	1
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Oct	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	1	1	1	1
Nov	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	1	1	1	1
Dec	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	1	1	1	1

Weekend

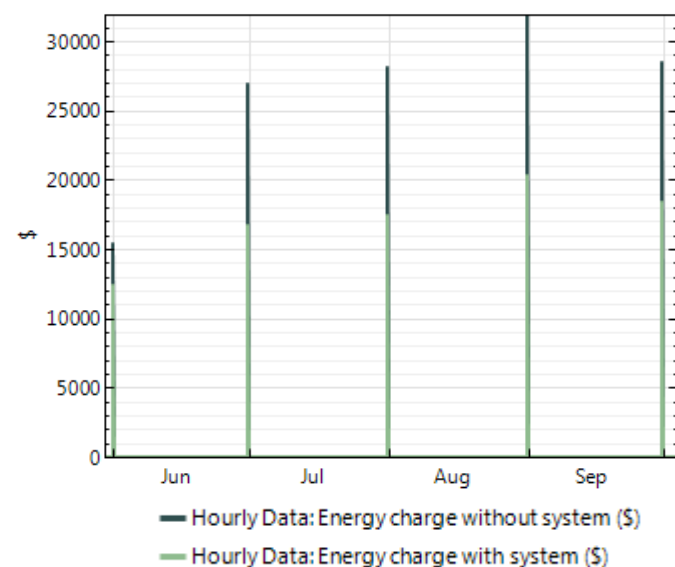
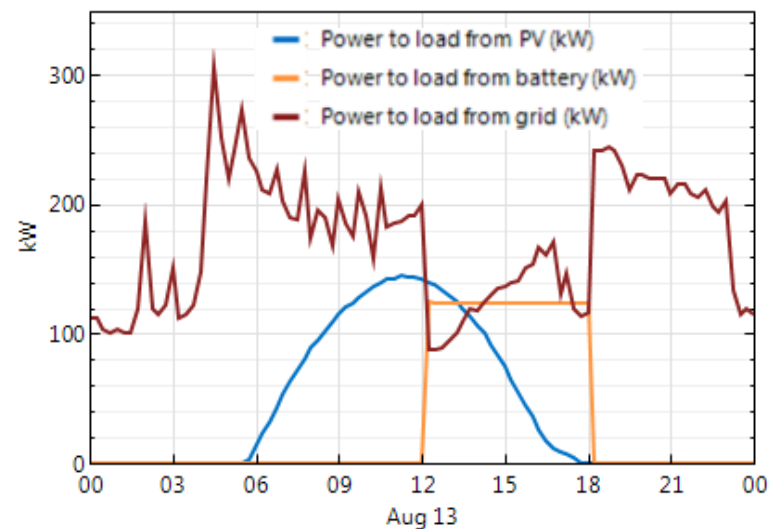
	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jul	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aug	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sep	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Oct	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nov	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dec	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Dispatch Visualization

Peak shaving for demand charge reduction



Manual dispatch for energy arbitrage



Example Case Study

- Evaluate economics of installing PV-coupled battery system for demand-charge reduction:
 - Los Angeles, CA
 - 27,625 ft² grocery store with 247 kW peak load
 - Southern California Edison TOU-GS-2 Option B

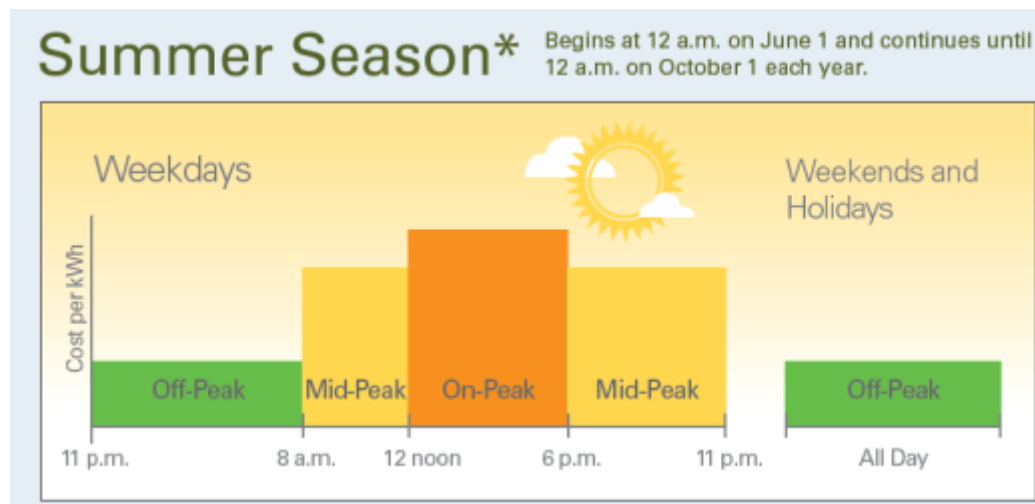
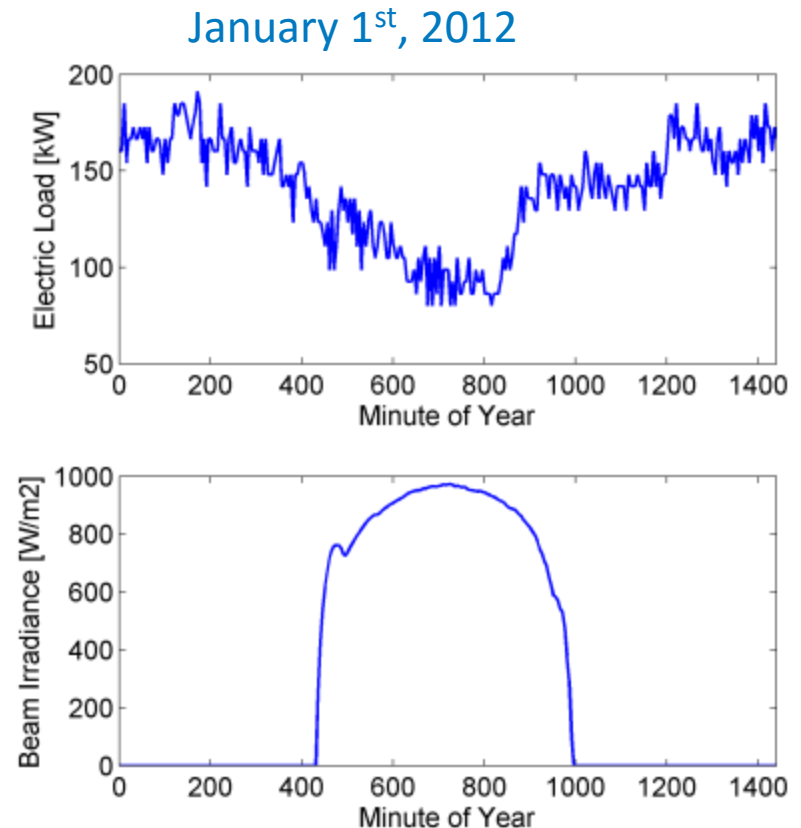


Image from SCE TOU-GS-2 Option B datasheet

Simulation Data

- One-minute weather data taken from NREL's Measurement & Instrumentation Data Center network, location in Los Angeles.
- Five-minute electric load data obtained from EnerNOC's free online database for commercial facilities.
- Assumed California's SGIP applied



Lithium Ion Battery System

- Model battery similar to Tesla Powerwall
 - Lithium-ion nickel manganese cobalt
 - Assumed can cycle full 7 kWh down to 30% of state-of-charge, for a full capacity of 10 kWh.
 - Price given as ~\$300/kWh before balance of system costs.
 - Assumed lifetime of 10-15 years before degrading to 70% of original capacity

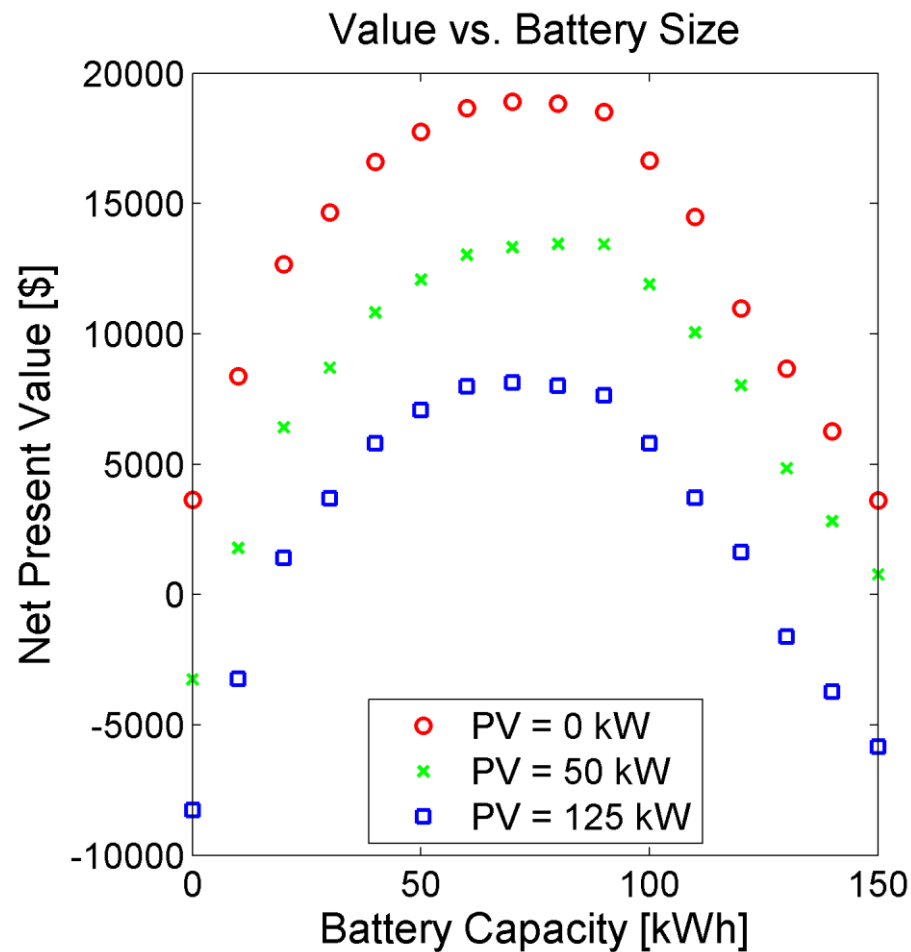
Table 3: Tesla Powerwall Specifications [13]

Property	Value
Price	\$3000
Capacity	7 kWh
Power	2.0 kW continuous, 3.3 kW peak
Efficiency	92%
Voltage	350 – 450 V
Current	5.8 A nominal, 8.6 A peak
Weight	100 kg
Dimensions	1300 mm x 860 mm x 180 mm



Image from teslamotors.com/powerwall

Parametric sizing results

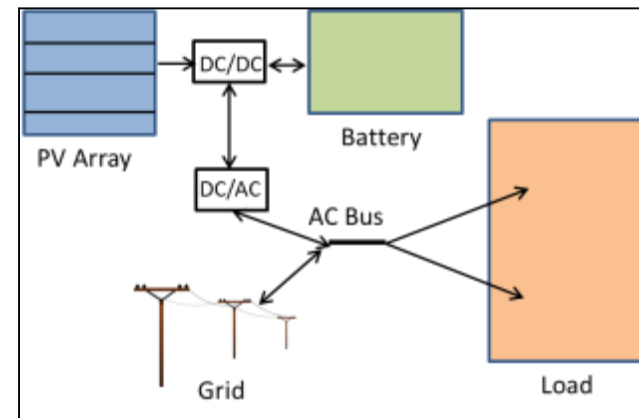


- NPV maximized for no PV system, battery bank capacity of 70 kWh
- Illustrates simulation-based method to approximate 'optimal' sizing.

Upcoming features

- Additional system configurations
- Additional battery chemistries
- Battery systems for PPA financial models
- Continued improvement of dispatch controllers
- Improved lifetime modeling for some battery chemistries

DC-connected battery



Flow batteries

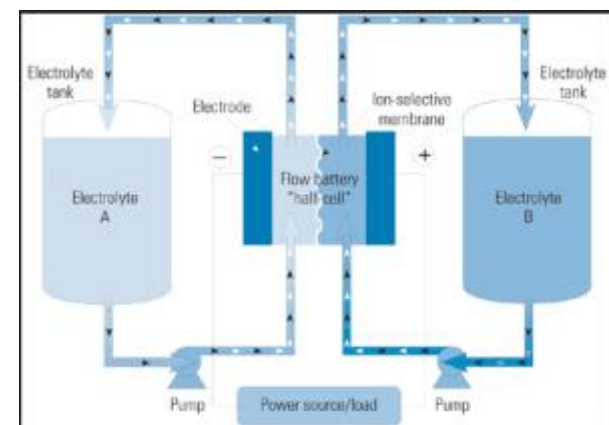


Image from tantaline.com

Battery summary

- Battery model adds on to SAM's powerful PV and inverter modeling capabilities to evaluate behind-the-meter storage systems.
- Can answer questions like:
 - What sizes of battery/PV system will provide value over the system lifetime?
 - How will battery replacement costs affect economic viability?
 - How does the dispatch strategy affect bill savings?

Questions?

- Resources:
 - <https://sam.nrel.gov/learning>
 - <https://sam.nrel.gov/videos>
 - <https://sam.nrel.gov/webinars>
- Reports available
 - Economic Analysis Case Studies of Battery Energy Storage with SAM
 - <http://www.nrel.gov/docs/fy16osti/64987.pdf>
 - Technoeconomic Modeling of Battery Energy Storage in SAM
 - <http://www.nrel.gov/docs/fy15osti/64641.pdf>

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